Enhanced Visualization of Production Systems Concepts and Simulation Data for the Smart/Digital Factory

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ABSTRACT

Aircraft maintenance, repair, and overhaul (MRO) ensures the continuing airworthiness of aircraft or aircraft parts. Aircraft MRO is extremely costly: the U.S. Air Force spends most of its lifecycle costs to sustain, versus acquire, its aircraft. A key component of Smart Manufacturing for MRO is the use of new software tools for analyzing and exploiting manufacturing knowledge and data more effectively.

This abstract describes two new analytic tools developed for the U.S. Air Force, enhanced with data visualizations, to enable more effective MRO production systems design and operations.

Selecting appropriate mitigations to production disruptions is challenging because the relationship between control decisions and the resulting performance is delayed and non-linear. The Short-Term Flow Planning Tool helps analysts understand and plan for current and hypothetical changes and disruptions, such as equipment outages, by simulating the effects of various capacity adjustments, induction rates, part scrap rates, and buffer sizes on WIP, part processing rates, and part transfer rates for each process step and day during the planning period. To help analysts interpret this multivariate data, the Tool provides a set of complementary data displays, including heat maps (Figure 1), arrays of timelines and time series graphs (Figure 2), and animated bar graphs (Figure 3) which show snapshots of daily production status and performance.

The operations management research literature provides many insights into manufacturing system behavior as well as methods for improving system performance. Unfortunately, many of these results have not been used by practitioners.

Based on operations management principles, the Diagnostic Tree (D-tree) provides a systematic way of reviewing possible ways of improving a production system. A D-tree is composed of nodes which each describe a performance improvement objective. Many of the nodes are linked to sub-nodes that describe more concrete sub-objectives for achieving the objective and describe how the objective's metric varies with the values of its sub-objective metrics. To help analysts understand these multivariate relationships, a sensitivity analysis function at selected nodes shows how the objective function varies with a user-selected variable, fixing the other variables at user-specified values. The dialog in Figure 1 prompts the user for values of the sub-objectives, and the graph in Figure 2 shows how the objective variable varies with the range variable -- in this case, sequential process batch size.

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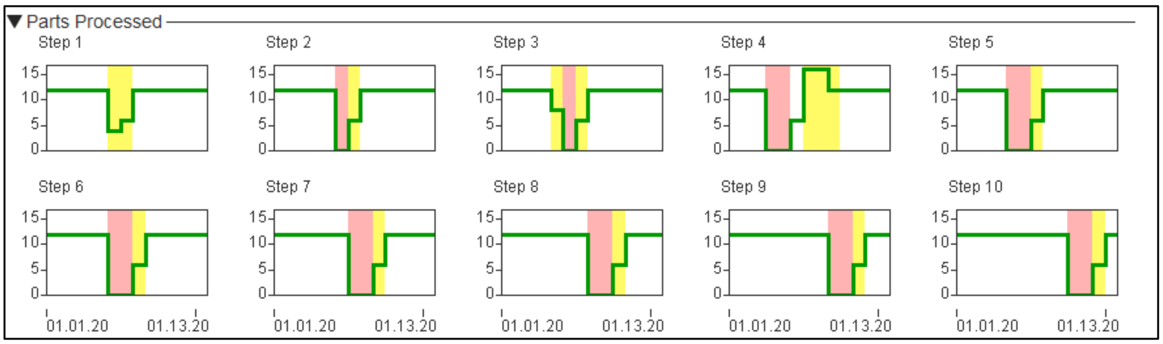
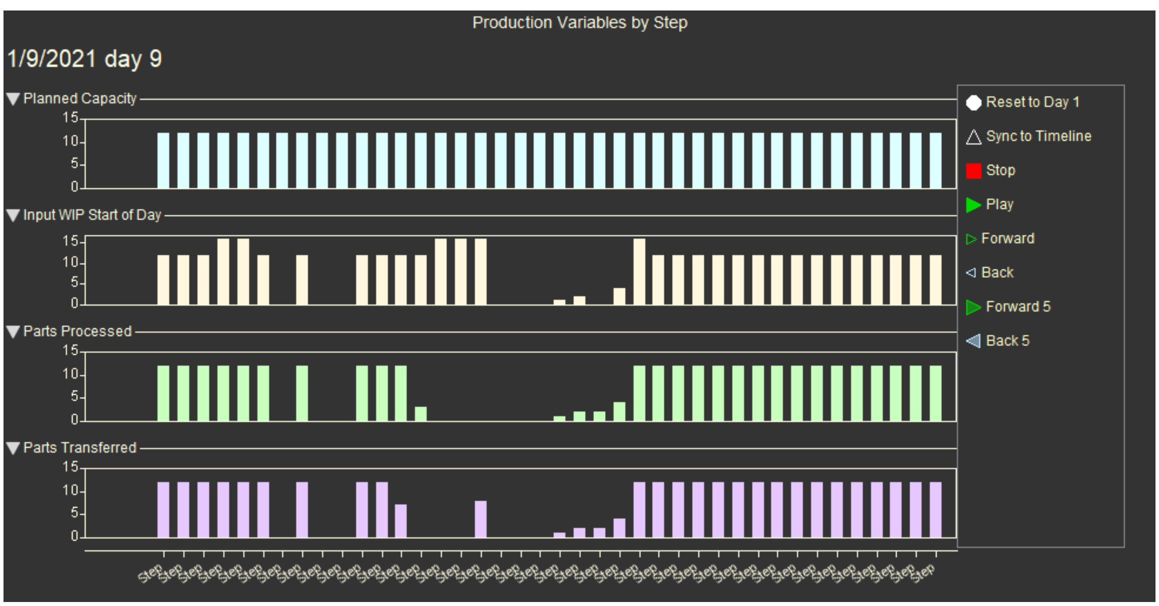
	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
1	**Parts Processed**															
2		1	2	3	4	5	6	7	8	9	10	11	12	13	14	
3		1/1	1/2	1/3	1/4	1/5	1/6	1/7	1/8	1/9	1/10	1/11	1/12	1/13	1/14	Sum
4	Step 1	12	12	12	12	12	4	0	12	12	12	12	12	12	12	148
5	Step 2	12	12	12	12	12	0	0	12	12	12	12	12	12	12	144
6	Step 3	12	12	12	12	8	0	0	12	12	12	12	12	12	12	140
7	Step 4	12	12	12	0	0	0	16	16	12	12	12	12	12	12	140
8	Step 5	12	12	12	12	0	0	0	12	12	12	12	12	12	12	132
9	Step 6	12	12	12	12	12	0	0	0	12	12	12	12	12	12	132
10	Step 7	12	12	12	12	12	12	0	0	0	12	12	12	12	12	132
11	Step 8	12	12	12	12	12	12	12	0	0	0	12	12	12	12	132
12	Step 9	12	12	12	12	12	12	12	12	0	0	0	12	12	12	132
13	Step 10	12	12	12	12	12	12	12	12	12	0	0	0	12	12	132
14	Sum	120	120	120	108	92	52	52	88	84	84	96	108	120	120	1364





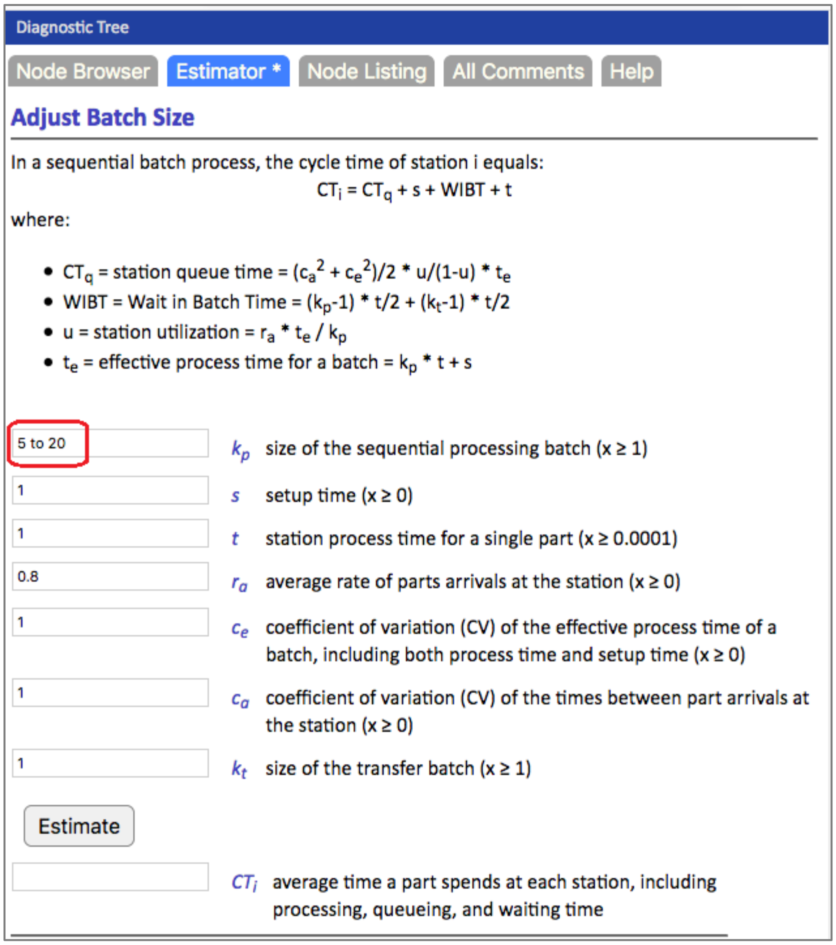


Figure 4 –D-Tree Estimator Inputs Specify a Range for Batch Size (k_p)

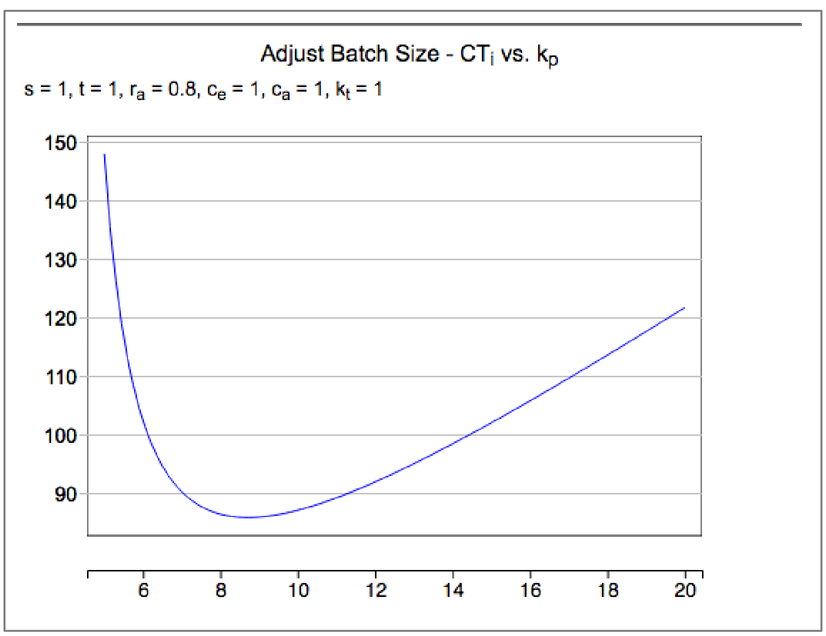


Figure 5 – D-Tree XY Graph Shows How Station Cycle Time Varies with Batch Size at User-Specified Values of other Variables